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# NASA TECH BRIEF



## Several New Catalysts for Reduction of Oxygen in Fuel Cells

Three groups of compounds have been found to be efficient electrocatalysts for the reduction of oxygen in alkaline electrolytes in low-temperature fuel cells: nickel carbide or nitride, or nickel-cobalt carbide; titanium nitride or carbide; and intermetallic compounds of the transition or noble metals.

Nickel or Nickel-Cobalt Compounds: Carbides or nitrides of nickel, or nickel-cobalt carbides, are good catalysts for $O_2$ (air) cathodes for alkaline $H_2$-$O_2$ fuel cells.

Nickel nitride ($Ni_3N$) was prepared by reaction of $NH_3$ with carbonyl nickel powder at 300°C; $Ni_3C$ and (Ni,Co)C, by decomposition of the acetates. The resultant powdered materials, bonded to nickel screens with a TFE fluorocarbon as the bonding and waterproofing agent, were sintered for 5 min at 300° C. Electrode pieces measuring 1 $cm^2$ in surface area were tested as half-cells in a "floating electrode" cell which consists of a reaction chamber in which the test electrodes are "floated" on the surface of a 35% aqueous solution of KOH at 75°C; $O_2$ is passed over the back of the test electrode in the reaction chamber.

The test electrode is driven potentiostatically against a large counter electrode; that is, by regulation of the potential between test electrode and a reference hydrogen electrode. The potential is swept slowly from 1000 mV to about 500 mV and back to 1000 mV, while the current is measured between the floating electrode and the counter electrode. The derived current-potential curves show surprisingly high performance. Work is proceeding on optimization of the conditions of preparation.

Titanium Nitride or Carbide: These compounds also are efficient electrocatalysts in low-temperature $H_2$-$O_2$ fuel cells; in addition to reduction of $O_2$, they show resistance to corrosion in the potential regions of interest in alkaline electrolytes and serve as third-electrode oxygen-scavengers in alkaline batteries.

The electrodes were tested as rotating-disk electrodes immersed in a 2*M* solution of KOH saturated with either $N_2$ or $O_2$. By imposition of a linear potential scan between the test electrode and a hydrogen reference electrode (by means of a slow linear potential signal to a potentiostat), the $i(E)$ or current-versus-potential curves were generated and recorded directly on an $x$-$y$ plotter.

Before a test of activity the corrosion current was measured under gaseous $N_2$ at a series of potentials; it had to be measured with stirring so that it could be subtracted quantitatively from the oxygen-reduction current. After measurement of the corrosion current, the electrode was removed from the system and repolished, and the solution was saturated with $O_2$ for at least 45 min.

The repolished sample was introduced into the electrolyte at a potential of 1.23 V, and the $i(E)$ curve was initiated in the direction of decreasing potentials. At $E = 0$, the direction of the potential sweep was reversed.

Transition and Noble Metals: Intermetallic compounds of the transition and noble metals (Pt, Pd, Au) are good alkaline-electrolyte catalysts for the electro-chemical reduction of $O_2$ in low-temperature fuel cells; they include $Ti_3Au$, $TaPt_3$, $TaPt_2$, $VPt_3$, $CoPt_3$, $NbPt_3$, $TiIr_3$, $ZrAu_3$, and $TaPd_3$.

The compound $Ti_3Au$ is especially advantageous because it contains no Pt and is almost 50% Ti by weight. Many of the intermetallics containing Pt show little or no loss of activity in $O_2$ reduction due to dilution of the Pt, and $Ti_3Au$ shows strong indications

(continued overleaf)

of being a better electrocatalyst than Pt. The surface composition of the catalyst may differ from the bulk composition.

In fact, optimization of these catalysts for practical electrodes may require changes in the ratios of non-noble metals—and especially so in $Ti_3Au$ in which the atomic ratio of 3:1 does not seem to be optimal.

## Notes:

1. This information may interest designers or manufacturers of fuel cells or batteries, and power or gas companies.
2. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

   Reference:
   NASA-CR-97624 (N69-10585), Development of Cathodic Electrocatalysts for Use in Low Temperature $H_2/O_2$ Fuel Cells with an Alkaline Electrolyte

## Patent status:

Inquiries about rights for commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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